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ABSTRACT

The second of four symposium papers brings together the results of four separate statistical analyses of findings on computer-based instruction (CBI) in 199 comparative studies, of which 32 were conducted in elementary schools, 42 in high schools, 101 in universities and colleges, and 24 in adult education settings. Each was a controlled, quantitative study which met predefined standards for methodological adequacy. The following results and study features were observed: (1) students generally learned more in classes in which they received CBI; (2) students learned their lessons with less instructional time in classes in which they received CBI; (3) students liked classes more when they received computer help; (4) students developed more positive attitudes toward computers when they received help from them in school; (5) computers had little effect in the areas of course withdrawal and attitude toward subject matter; (6) study results were consistently stronger in published studies than in those that were not published; (7) effects were greater when different teachers taught experimental and control groups; (8) effects tended to be greater in more recent and in short studies; and (9) effects were somewhat greater in studies reported in journal articles than in dissertations. It is suggested that editorial screening, experimental design flaws, and instructional quality may have contributed to this favorable picture of CBI. The four meta-analyses are listed as references. (MES)

COMPUTER-BASED INSTRUCTION: WHAT 200 EVALUATIONS SAY

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Many people believe that computer technology will change society in the years ahead as completely as the invention of the printing press did 500 years ago or as the invention of writing did thousands of years ago. These earlier inventions gave people new ways of encoding, storing, and retrieving information, and they ultimately changed the way people worked, the way they played, and probably even the way they thought. Computers have also given us a radically different way of handling information, and so it seems inevitable that they too will dramatically alter the way we lead our lives.

Educational researchers and developers therefore are no longer asking *whether* a computer revolution will occur in education. They are asking instead *how* it will occur. Will the changes in education come swiftly and smoothly, or will education's transition to the computer age be full of false starts and costly mistakes? How long will it take for educators to start using the computer well?

During the past two decades, hundreds of educators and evaluators have examined the effectiveness of programs of computer-based teaching. We joined this effort because we believe that adapting to the computer age is one of the major challenges facing schools today and that evaluation studies can help schools meet this challenge. Our approach was to analyze statistically, or meta-analyze, findings from as many evaluation studies of computer-based instruction as we could find. Our purpose was to provide teachers, researchers, and policy makers with an overview of what educators have accomplished to date with computer-based instruction.

We carried out four separate statistical analyses of findings on computer-based instruction (Bangert-Drowns, Kulik, & Kulik, 1985, C. Kulik & Kulik, in press; C. Kulik, Kulik, & Shwalb, 1986; J. Kulik, Kulik, & Bangert-Drowns, 1985). These analyses covered a total of 199 comparative studies: 32 in elementary schools; 42 in high schools; 101 in universities and colleges; and 24 in adult education settings. Each of the 199 studies included in our analyses was a controlled, quantitative study that met our predefined standards for methodological adequacy. The studies covered use of the computer in (a) computer-assisted instruction, or CAI, including drill-and-practice and tutorial instruction; (b) computer-managed instruction, or CMI; and (c) computer-enriched instruction, or CEI, including the use of the computer as a calculating device, programming tool, and simulator.

Overall Results

Most of the studies reported that computer-based instruction has positive effects on students.

1. Students generally learned more in classes in which they received computer-based instruction. The average effect of computer-based instruction in all 199 studies was to raise examination scores by 0.31 standard deviations, or from the 50th to the 61st percentile.

2. Students also learned their lessons with less instructional time. The average reduction in instructional time in 28 investigations of this point was 32%.

3. Students also liked their classes more when they received computer help. The average effect of computer-based instruction in 17 studies was to raise attitude-toward-instruction scores by 0.28 standard deviations.

4. Students developed more positive attitudes toward computers when they received help from them in school. The average effect size in 17 studies on attitude toward computers was 0.33.

5. Computers did not, however, have positive effects in every area in which they were studied. The average effect of computer-based instruction in 29 studies of attitude toward subject matter was near zero, and the average effect was also near zero in 23 studies of course withdrawals.

Study Features and Outcomes

A few study features were consistently related to outcomes of computer-based education.

1. Study results were consistently stronger in published studies and weaker in unpublished ones ($p < .01$). The average effect of computer-based instruction in published studies was to raise student examination scores by 0.46 standard deviations, whereas its average effect in unpublished studies was to raise scores by only 0.23 standard deviations.

2. Effects were larger when different teachers taught the experimental and control groups ($p < .05$). Effects were smaller when the same teacher was responsible for both groups. With the same teacher in charge of experimental and control groups, average size of effect on examination scores was 0.24 standard deviations. With different teachers in charge of the groups, the average effect was 0.40 standard deviations.

3. Effects tended to be larger in more recent studies and smaller in older studies ($p < .05$). The average effect of computer-based instruction in studies published before 1975 was to raise examination scores by 0.24 standard deviations; the average effect in studies published in later years was a score increase of 0.36 standard deviations.

4. Effects were also somewhat larger in short studies and weaker in longer ones ($.10 < p < .20$). The average effect of computer-based instruction in short studies was to raise examination scores by 0.36 standard deviations, whereas its average effect in longer studies was to raise scores by 0.27 standard deviations.

Because study features were moderately intercorrelated, multiple regression analyses were carried out on study feature data. In the multiple regression equation developed from the full data set, three of the four study factors had significant weights: publication source, control for instructor effects, and study duration. The regression weight for the fourth study feature—study year—reached a borderline level of significance.

Discussion

Why have evaluations of computer-based instruction produced such positive results? Several different factors might have contributed to the favorable picture in the literature:

Editorial gatekeeping. Journal editors and reviewers may prefer to publish strong and significant results rather than weak and insignificant ones.

Experimental design flaws: Design flaws in evaluation studies may allow researcher biases and expectations to color study results.

Instructional quality: The positive results from meta-analytic studies may reflect real differences in the quality of conventional and computer-based instruction.

Editorial Gatekeeping

If editorial gatekeepers base their publication decisions on the significance of study findings rather than on study quality, then published studies provide a distorted picture of what actually works in education. In such a case, an educator could get a better picture of what works from the clearinghouse literature, the dissertation literature, or—better yet—the file-drawer and wastebasket literature. The poorest guide to what works would be the most highly peer-reviewed literature.

Before throwing away the most respected literature in education, however, we should consider another possibility. The difference in results in published and unpublished reports may have another cause. We should remember that the authors of journal and dissertation studies are different individuals working under different circumstances. They differ in their research experience, in their resources, in their relationship to instructional developers, and in many other respects. Such differences can explain—just as well as editorial gatekeeping can—the differences in results found in dissertations and journals. It seems to us that we know too little about what lies behind the difference in journal and dissertation results to reject out-of-hand either kind of result.

Experimental Design

Can flaws in experimental design explain—or explain away—the positive findings from studies of computer-based instruction? Some reviewers think so. They believe that with imperfectly controlled experiments, positive results are more likely to occur than negative ones. Among the factors that might distort results in an imperfectly controlled evaluation are differences in time-on-task, self-selection differences in assignment to comparison groups, and uncontrolled teacher effects.

The evidence from our meta-analyses is that not all such factors are important. The positive results of evaluations of computer-based instruction cannot be attributed to differential time-on-task for comparison groups, for example. Studies that control for time-on-task have produced nearly the same results as studies without strict controls on instructional time. Actual records of instructional time have been collected in several studies, and these records suggest that students in computer groups often receive instruction for shorter periods than conventional students do.

Probably no other methodological point has received as much attention in evaluation research in recent years as the distinction between random experiments and quasi-experiments. Random experiments are generally thought to produce clear and consistent results; quasi-experiments are often thought to produce inconsistent and biased results. In our meta-analyses, random experiments and quasi-experiments produced the same results. Our meta-analytic results did not support the idea that the nature of subject assignment to groups is an important methodological flaw in evaluation studies of computer-based instruction.

Results from studies with and without controls for instructor effects are somewhat different, however. In the typical study with the same instructor teaching experimental and control classes, the effect of computer-based teaching seemed modest. In the typical study with different instructors in experimental and control classes, the effect of computer-based teaching seemed more substantial.

Why should one-instructor and two-instructor experiments produce somewhat different results? It is not at all obvious to us. It may be, for example, that in two-instructor experiments, the poorer instructor is usually assigned to the control condition and the better instructor to the experimental condition, and the difference between conditions is magnified because of these teacher assignments. If this is the case, then one-instructor studies more accurately assess the effects of computer-based instruction. It may also be, however, that in one-instructor studies there is diffusion of the innovative treatment to the control condition. Involvement of a teacher in an innovative approach to instruction may have a general effect on the quality of the instructor's teaching. Outlining objectives, constructing lessons, preparing evaluation materials, and working with computer materials—requirements in computer-based instruction—may help a teacher to do a better job in a conventional teaching assignment. If this is the case, two-instructor studies provide the better basis for estimating the size of an experimental effect.

Instructional Design

Computer-based instruction is often well-designed instruction. The hard work of an instructional design teams often ensures the quality of computer materials. Objectives are usually clear and explicit. Instruction is carefully sequenced. The materials engage the learner's attention and encourage learner activity. The program provides frequent feedback to the learner. Instructional design teams often spend 100 hours developing just one hour of computer lessons.

Certain features of the computer make it an especially attractive medium for instructional designers. Computers can generate attractive and complex graphics quickly. Computers can simulate motion. They can give undivided attention to a single learner. They can provide complex evaluations of a learner's performance. They can wait patiently. They can be programmed to model a learner's cognitive processes.

In certain respects, computer lessons seem to have an advantage over lessons presented by classroom teachers. Few classroom teachers can put 100 hours of preparation time into each one-hour lesson. Classroom teachers cannot give each individual in a large classroom their continuous, undivided attention. Classroom teachers can be notoriously slow at grading student work and preparing reports. And their patience is often tried by their students.

Can such differences account for the superior record of computer-based instruction in evaluation studies? They might. It is possible that the computer has fared so well in evaluation studies because programs of computer-based instruction have generally been well-designed, and computers have delivered instruction in an attractive and engaging way. It is possible, in other words, that we should take the findings of studies of computer-based instruction at face value, and conclude that the computer has so far been an excellent vehicle for the delivery of instruction.

Conclusions

Among the conclusions that can be drawn from our analysis, the following three seem especially important to me:

1. Most programs of computer-based instruction evaluated in the past have produced positive effects on student learning and attitudes. Future programs for developing and implementing computer-based instruction should therefore be encouraged. If such programs are as carefully designed as current programs are, they will most likely produce positive results.

2. Both journal articles and dissertations present a basically positive picture of results of computer-based instruction, but the findings reported in journal articles are clearly more favorable. Researchers should give high priority to finding out what factors produce differences in journal and dissertation results. Does editorial gatekeeping lead professional journals to present a distorted picture of social science findings? Or do dissertation authors simply measure experimental effects less well than do more seasoned researchers?

3. Although a variety of different research designs can be used to show the effectiveness of computer-based instruction, certain research designs seem to produce more positive results. Studies where the same instructor teaches both experimental and control classes, for example, report somewhat weaker effects than do studies with different experimental and control teachers. Studies of long duration often report weaker effects than do short studies. Reasons for the difference in results from studies using different experimental designs are not well understood, however. Research on such factors should be encouraged.

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